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SEQUESTRATION PARTNERSHIP

A New Energy Future for Montana, Idaho, South Dakota, Wyoming, the Pacific Northwest and the Nation

# $CO_2$ Sequestration in Saline Formations:
# Grand Ronde Basalt, Big Sky

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# Technical Lead and Partners

- **BSCSP Lead: B. Peter McGrail, Battelle Pacific Northwest Division**
- **Field Test Partners: BSU, INL, ISU, LDEO, LANL, UI**
- **Field Test Information:**
  - **Field Test Name: Basalt and Mafic Rock Field Validation Test**
  - **Test Location: Eastern Washington State**
  - **Amount and Source of $CO_2$: 3,000 MT**

# Cost and Key Dates

- **Total Field Project Cost:** $6,238K
  - **DOE Share:** $5145.2K 84%
  - **Non-Doe Share:** $993.2 16%
  - *Does not include TBD cost share associated with Drilling, CO2 purchase, and MMV.
- **Field Project Key Dates**
  - **Baseline Completed:** 11/30/2006
  - **Drilling Operations Begin:** 12/30/06
  - **Injection Operations Begin:** Fall 2007
  - **MMV Events:**
    - 3/31/2006 - Workshop
    - 6/30/2007 - Baseline MMV
    - 12/30/2009 - Post Injection Coring

# BSCSP Geologic Approach

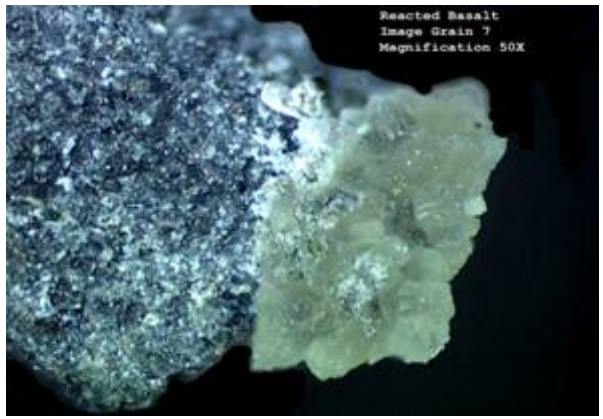
- Take advantage of reactive properties of $CO_2$
  - Identify sequestration targets with multiple trapping mechanisms (hydrodynamic, solubility, mineralization)
  - Emphasize mineral or other chemical reaction trapping
- Develop robust geologic sequestration options to permanently store $CO_2$
  - Conversion to alkalinity and carbonate minerals

# Reactive Trapping of $CO_2$

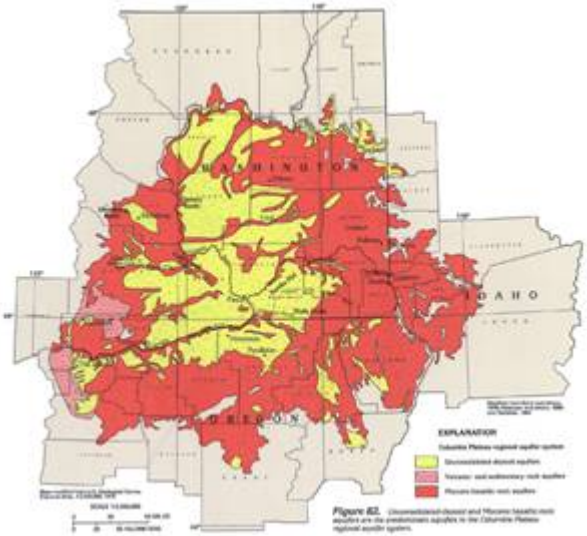
- $CO_2$ is converted to solid phase carbonate minerals (e.g., calcite) by accelerated rock weathering reactions

$$CaAl_2Si_2O_8 + H_2CO_3 + H_2O \rightarrow CaCO_3 + Al_2Si_2O_5(OH)_4$$

$$CaMgSi_2O_6 + Mg_2SiO_4 + 4H_2CO_3 \rightarrow Mg_3Ca(CO_3)_4 + 3SiO_2 + 4H_2O$$



# Rationale for Basalts

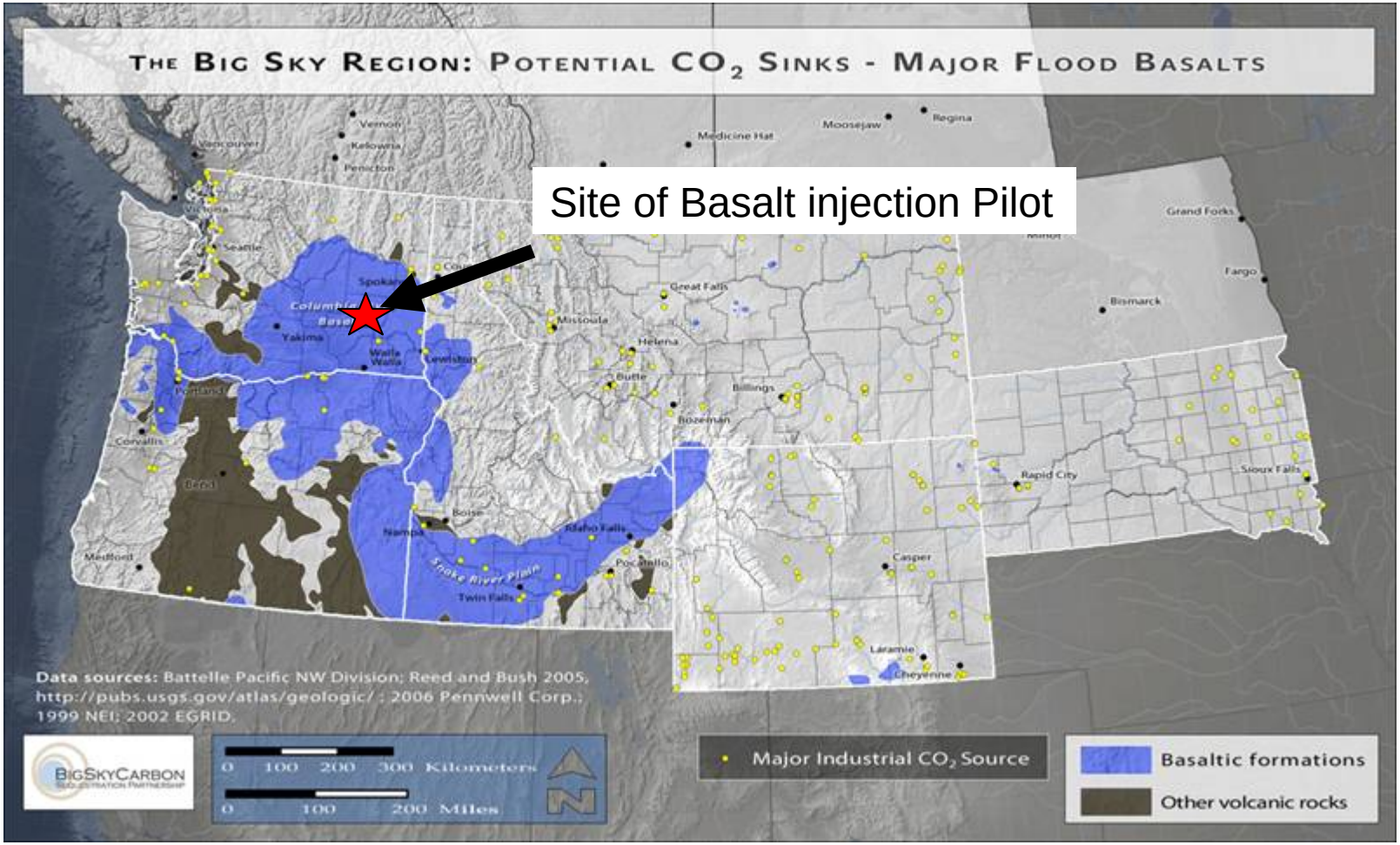



- Capacity and Retention
  - Columbia River Basalt Group covers 164,000 $km^2$, >174,000 $km^3$
  - Chemical makeup favorable for mineralization reactions
  - Large capacity
    - ~100 $GtCO_2$ storage capacity (McGrail et al. 2006)
    - 33-134 $GtCO_2$ storage capacity (GWG methodology)

# Growing Public and Industry Interest

- Energy Northwest
  - CO2 capacity estimates for IGCC plant
- Portland Energy
  - Public outreach
- Idaho Congressional inquiry
  - Carbon Sequestration Committee
- Puget Sound Energy
  - Public outreach
  - Board of directors meeting

# Location of Basalt Pilot

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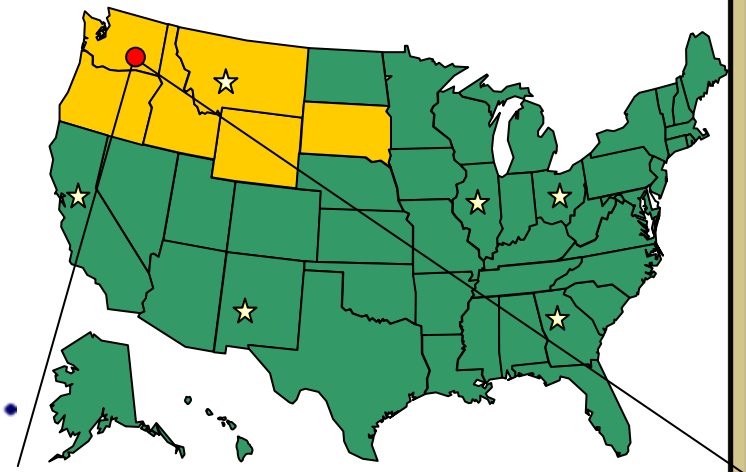
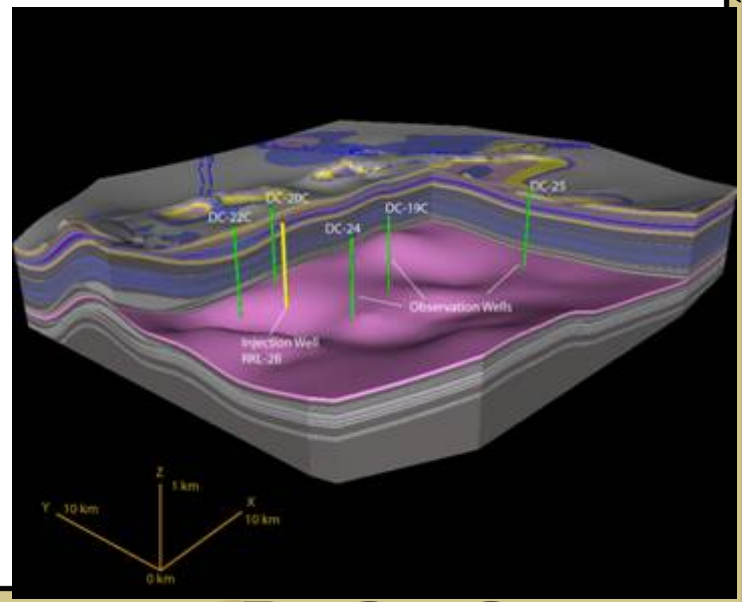
# Basalt and Mafic Rock Field Validation Test

- 3000 MT of $CO_2$ transported by rail from refinery
- Utilize existing deep well infrastructure to minimize drilling costs for injection and monitoring
- Target is Grande Ronde basalt formation (1100 m depth)
- Post injection core sampling to verify mineralization reactions
- Validate supercomputer simulations of $CO_2$ dispersion, dissolution, and trapping in basalt using suite of geophysical, hydrologic, and tracer methods



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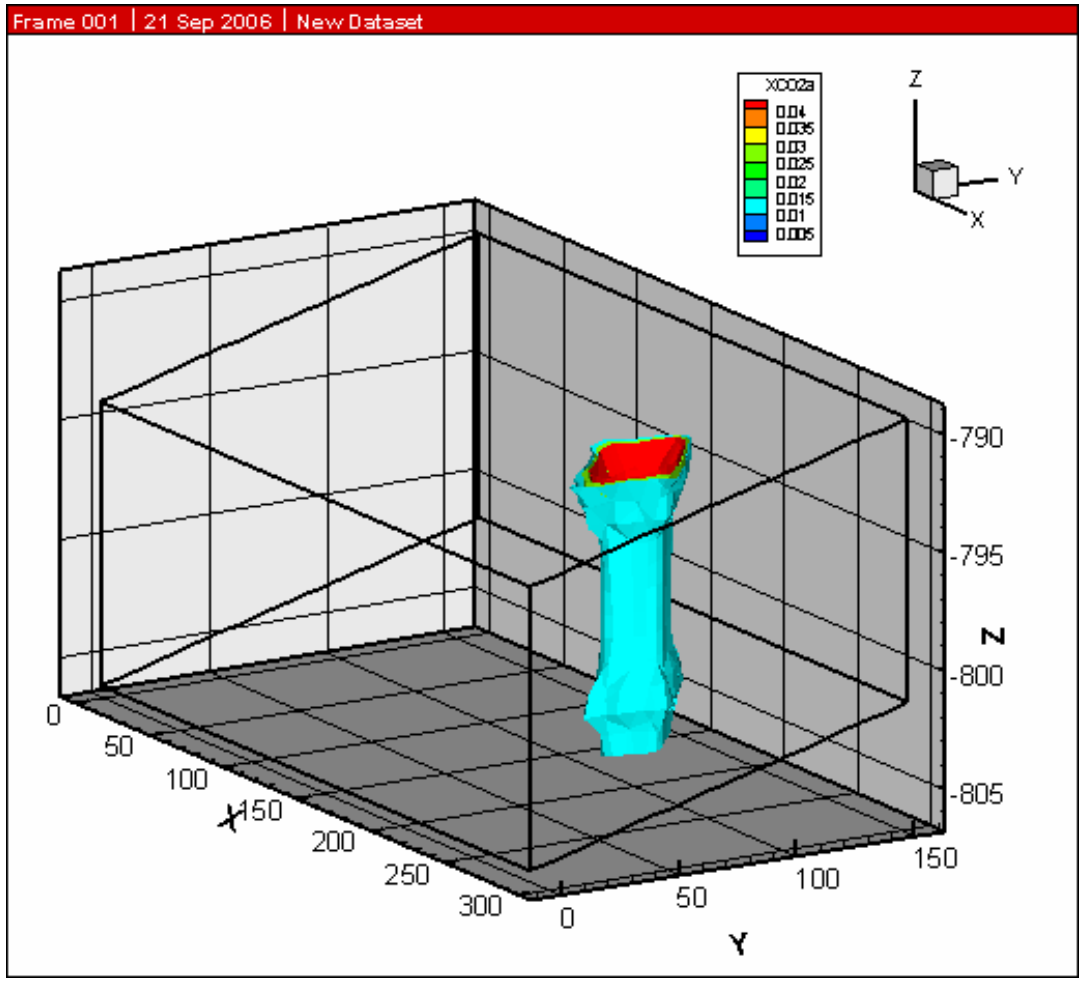
# Results to Date

- Transport models
  - TOUGHREACT
  - STOMP
- MMV Master Document
- Permitting
  - NEPA CX
  - State Injection well permit
- $CO_2$

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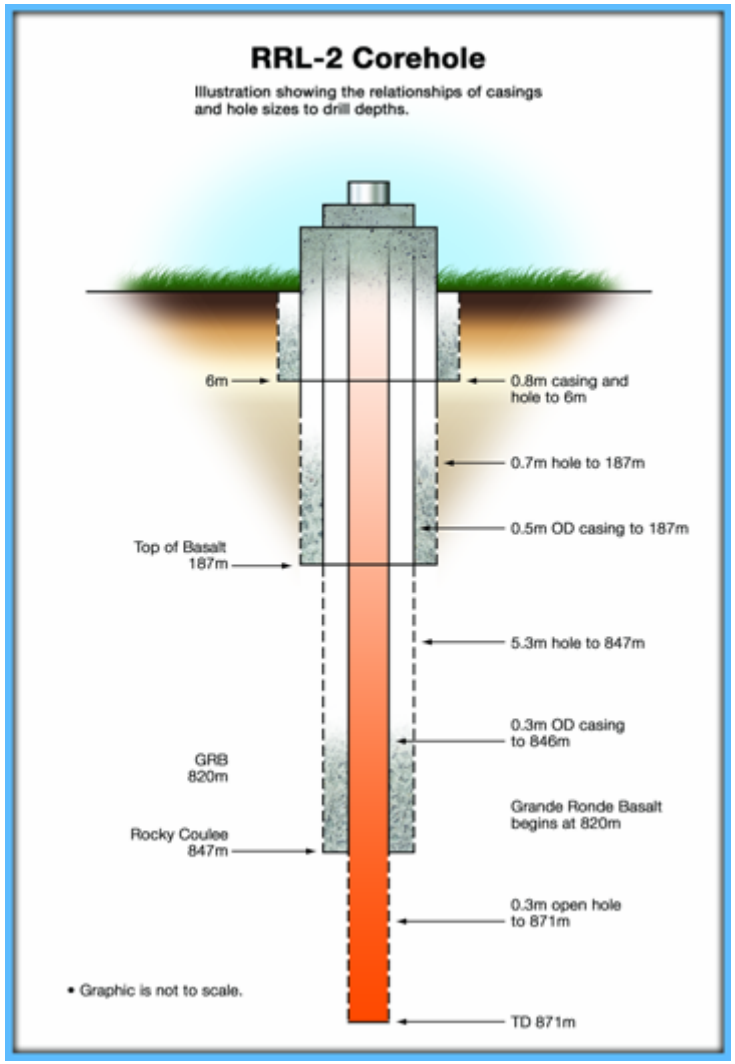
# Path Forward

- Drilling to begin 12/06
  - Significant cost savings
- MMV plan implemented
  - Norway
  - France
  - Russia
- Infrastructure assessment
  - Plumbing
  - Well completions
  - Sampling methods



# Schedule and Milestones

| Task 2.0 - Basalt and Mafic Rock Field Validation Test | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task 2.1 - Planning and Permitting | | | | | | | | | | | | | | | | |
| Pilot oversight and supervision | | | | | Gm5 | | | | | | | | | | | |
| Develop permitting material | | | Gm2 | | | | | | | | | | | | | |
| Pre injection modeling | | | | | | | | | | | | | | | | |
| Task 2.2 - Site Preparation and Characterization | | | | | | | | | | | | | | | | |
| Surface site preparation | | | | | | | | | | | | | | | | |
| Well development | | | | | | | | | | | | | | | | |
| Geochemical sampling and hydrological testing | | | | | | | | | | | | | | | | |
| Completion of pre-injection | | | | | | | | Gm20 | | | | | | | | |
| Task 2.3 - Injection | | | | | | | | | | | | | | | | |
| Purchase $CO_2$, tracer and equipment | | | | | | | | | | | | | | | | |
| Develop surface infrastructure | | | | | | | | | | | | | | | | |
| Conduct $CO_2$ injection | | | | | | | | Gm8 | | | | | | | | |
| Install well seal | | | | | | | | | Gm21 | | | | | | | |
| Task 2.4 - Site Monitoring and Verification | | | | | | | | | | | | | | | | |
| Develop MMV plan | | Gm1 | | | | | | | | | | | | | | |
| Conduct base line MMV | | | | | | | Gm7 | | | | | | | | | |
| Collect and analyze post injection fluid samples | | | | | | | | | | | | | | | | |
| Conduct surface based monitoring | | | | | | | | | | | | | | | | |
| Drill deviated core hole; conduct core and core hole analyses | | | | | | | | | | | | | | | Gm15 | |
| Post injection modeling and data interpretation | | | | | | | | | | | | | | | | Gm16 |

| | | |
|---|---|---|
| Gm1 | 3/31/2006 | Convene Basalt Pilot MMV Kick-Off Meeting with international partners |
| Gm2 | 6/30/2006 | Complete and submit application for Class V Basalt Pilot injection well permit |
| | 9/30/06 | Issue NEPA CX Application documents |
| Gm5 | 12/31/2006 | Complete and submit detailed project design package for Basalt Pilot to DOE<br>Commence drilling operations |
| Gm7 | 6/30/2007 | Complete and document Basalt Pilot site base line MMV characterization |
| Gm8 | 9/30/2007 | Initiate injection of carbon dioxide for Basalt Pilot |
| Gm15 | 6/30/2009 | Collect Basalt Pilot post injection core |
| Gm20 | 9/30/2007 | Completion of pre-injection testing |
| Gm21 | 12/31/2007 | Install well seal |
| Gm16 | 9/30/2009 | Complete final topical report on field Basalt Pilot validation test |

# Key Issues

- Permitting
  - Injection permit 6 months?
    - Educate regulators
- Increased drilling cost
  - Rig time
  - Steel
  - Availability
- $CO_2$ direct negotiations